Transport Canada
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TP 7655E

Vancouver Computerized Scheduling/Brokerage Demonstration Project

Summary Report

Prepared for
Transportation
Development Centre

and

BC Transit

by

TransVision Consultants Ltd.

MARCH 1987

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VANCOUVER COMPUTERIZED SCHEDULING/BROKERAGE DEMONSTRATION PROJECT SUMMARY REPORT

Prepared for the
Transportation Development Centre
and BC Transit
by Tom Geehan, TransVision Consultants Ltd.

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"The contents of this report reflect the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre, Transport Canada or BC Transit."

Ce document est également disponible en français.

Other reports on the Computerized Scheduling/Brokerage Demonstration Project in Vancouver:

Application of Computers to Special Transit Services: A Review (TP6856E), August 1985.

DART Manager: User Manual (TP6884E), August 1985.

DART Manager Plus: User Manual (TP7659E), May 1987.

DART Manager Graphics: User Manual (TP7656E), March 1987.

Vancouver Computerized Scheduling/Brokerage Demonstration Project Final Evaluation Report (TP7657E), March 1987.

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17. Abstract

In March 1985, the Transportation Development Centre of Transport Canada and British Columbia Transit initiated a jointly sponsored demonstration of computerized scheduling/brokerage systems in order to improve the quality and cost-effectiveness of transit services for disabled persons.

Two microcomputer-based systems were demonstrated. One of the systems operated on a local area network and used low-cost graphical display technology to improve the scheduling/dispatching function in special services. The other system provided scheduling assistance through a tabular display of schedules and was a multi-user system.

This report provides an overview of the project, focusing on the two microcomputer applications. The project approach and organization, applications setting, implementation procedures and impacts, results and conclusions of the project are described.

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17. Résumé

En mars 1985, le CDT et British Columbia Transit ont lancé un projet conjoint d'exploitation expérimentale de divers systèmes de régulation/gestion assistées par ordinateurs, destinés à relever la qualité et la rentabilité des services de transport pour handicapés.

L'expérience a porté sur deux systèmes pilotés par micro-ordinateur. Le premier fonctionnait, dans une configuration mono-utilisateur, en réseau local et mettait en oeuvre une technologie d'affichage graphique à faible coût destinée à améliorer les fonctions établissement d'horaire/affectation des véhicules d'un service de transport adapté. Le deuxième, conçu pour une configuration multiutilisateur, était un outil d'aide à l'établissement des horaires sous la forme d'un affichage tabulaire de ces derniers.

Ce rapport passe en revue les travaux, mettant l'accent sur les deux systèmes micro-informatiques. Il décrit l'approche retenue, l'organisation des travaux, le contexte de l'expérimentation, les méthodes d'implantation des systèmes et les répercussions de l'informatisation ainsi que les résultats et conclusions de l'expérience.

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The author would also like to gratefully acknowledge the assistance of **Keith Miller** of BC Transit who kept the project on track and made it a pleasure for all involved and **Helen Cook** of BC Transit who took Keith's place at the end of the project.

INTRODUCTION

Improvements and expansion of transit services for the disabled are often limited, not by demand (which usually exceeds the supply), but by the efficiency of operations. These services rely heavily on management and control of the demand by means of eligibility criteria, ride prioritization, and other service constraints. To provide effective and efficient service with appropriate improvements in service quality requires better responsiveness in dealing with trip demands or better control and management of the supply of services. Matching the supply of available vehicles with the demand for trips, while making the most effective use of limited resources, is the challenge faced daily by managers of special transit services.

In March, 1985, in order to foster the development of technology to improve transportation services for elderly and disabled persons, the Transportation Development Centre of Transport Canada and British Columbia Transit initiated a two-year scheduling and brokerage demonstration project in Vancouver. The specific objective was to improve the quality and cost-effectiveness of transit services for the disabled through the selection, implementation and demonstration of computer-assisted systems with particular emphasis on the best application of microcomputer technology to special transit services.

The project schedule covered twenty-four months, beginning in April, 1985, and ending in March, 1987. The project budget was $525,000, of which $300,000 was provided by Transport Canada and $225,000 by BC Transit. This budget covered expenditures for system development for two computer systems, hardware procurement, preparation and distribution of user manuals and programs, report preparation and dissemination, and BC Transit and operating company staff time.

The end products of the demonstration project included two computer software packages for special transit service operators; user manuals; a report on computer-aided scheduling of special transit services in Canada; a report on the demonstration project; an audio-visual presentation describing the project; and this summary report.

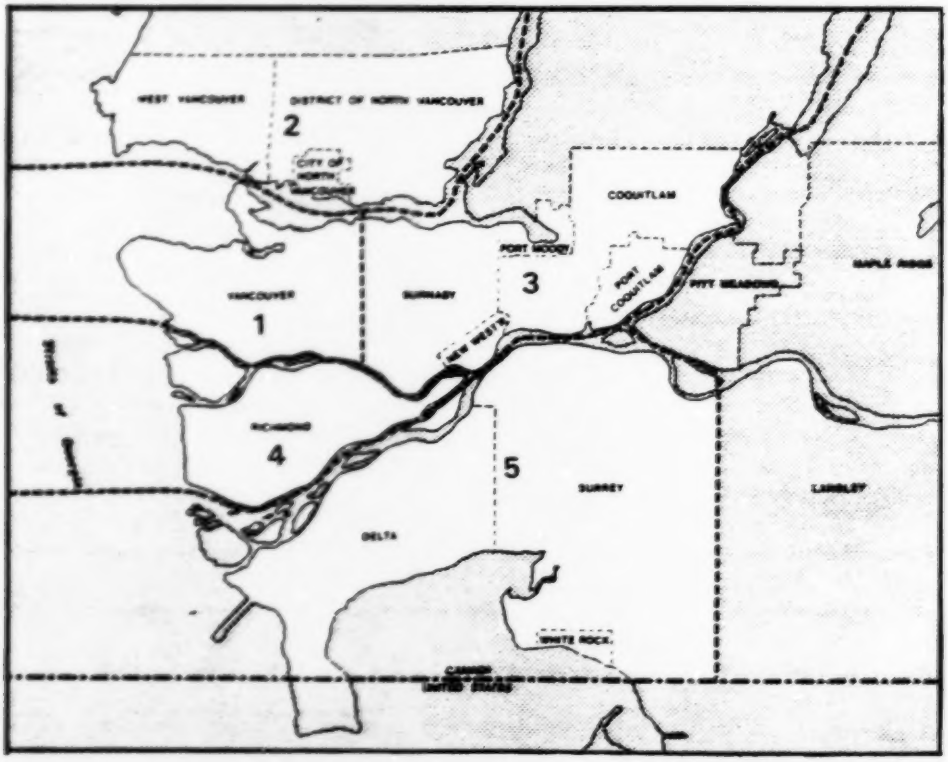
The demonstration project illustrated the feasibility of using microcomputers in smaller custom transit services. A reduction in operating costs of approximately five percent was achieved, and the benefits easily exceeded the cost of acquiring computers. The project also illustrated the difficulties involved in developing new systems and the ease with which custom transit operators can adapt to and use new technology to improve service for clients.

SETTING

BC Transit, a provincial Crown corporation responsible for all transit services in British Columbia, introduced the Custom Transit Program in 1980. The program provides a policy, funding and administrative framework for the provision of custom transit services in the province. BC Transit contracts with private companies or nonprofit societies to operate the services, supplies vehicles and equipment, assists in administration, and is responsible for service specifications, funding, planning, marketing, monitoring and evaluation activities.

The five service zones in the Vancouver Region are illustrated in Exhibit 1. In July, 1986, the operating companies serving these zones were (1) Zone 1: Pacific Transit Cooperative, (2) Zone 2: handyDART North Shore, (3) Zone 3: Western Society for Senior Citizens' Services, (4) Zone 4: Richmond Volunteer Transportation Society, (5) Zone 5: Deltassist Society, Surrey Community Resource Society, and White Rock Community Aid Society. The two operators participating in this demonstration project were the Western Society for Senior Citizens' Services in Zone 3, and North Shore handyDART in Zone 2.

EXHIBIT 1: CUSTOM TRANSIT SERVICE ZONES IN THE REGION



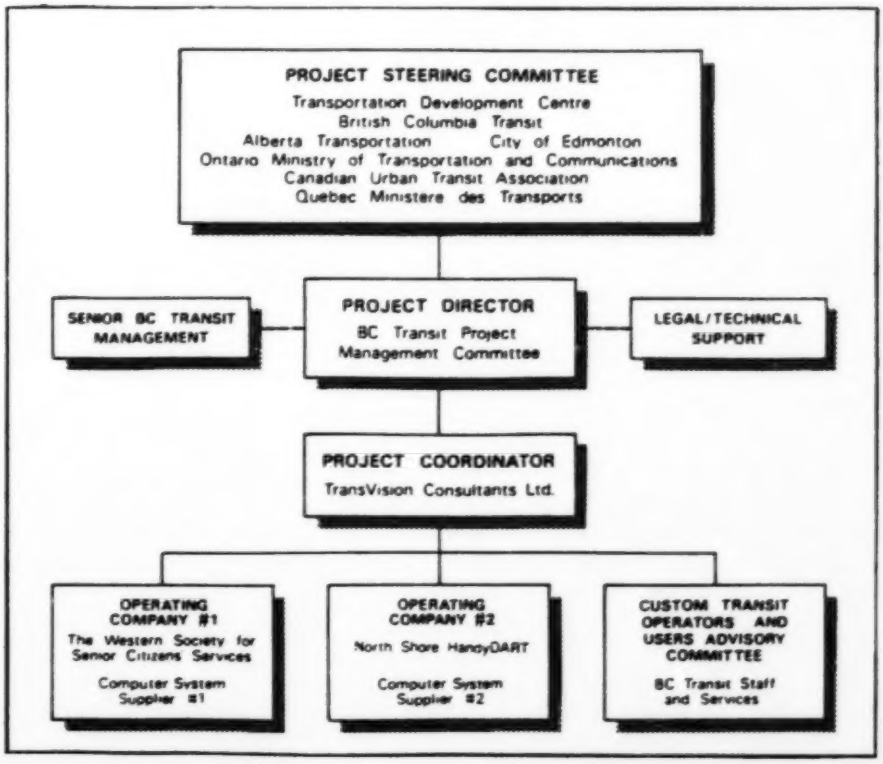
The Western Society for Senior Citizens' Services is a non-profit society administering various services for senior and disabled citizens in New Westminster, Burnaby, Coquitlam, Port Coquitlam and Port Moody. The Western Society has approximately 2,800 registered handyDART clients on file and provides approximately 350 trips per day. Office staff include an administrator, two dispatchers, a telephone receptionist and an assistant administrator who also does the bookkeeping. The fleet consists of 16 vehicles (14 vans and 2 cars). There are 14 full-time and 2 part-time drivers.

The North Shore handyDART service is operated by 3120 Ventures Limited and provides service in North Vancouver and West Vancouver. North Shore handyDART has approximately 900 registered clients and provides about 150 rides per day. Seven vehicles are used and nine drivers are employed. The office staff consists of a part-time office manager, a part-time accountant and a full-time scheduler/dispatcher.

ORGANIZATION

Project organization, consisting of a Steering Committee, BC Transit Management Committee, Users Advisory Committee, Project Coordinator and other support staff, is illustrated in Exhibit 2.

EXHIBIT 2: DEMONSTRATION PROJECT ORGANIZATION



The demonstration project was under the overall direction of a Steering Committee composed of representatives from the Transportation Development Centre, BC Transit, the Canadian Urban Transit Association, the City of Edmonton, and the provincial transportation ministries of Alberta, Ontario and Quebec.

The BC Transit Management Committee, comprised of senior BC Transit staff, undertook project monitoring, budget and contractual control, and coordination.

A users group, consisting of the custom transit operators, was involved in helping to design and implement the computer systems.

A Project Coordinator, TransVision Consultants Limited, was retained by BC Transit to provide detailed project monitoring, control, coordination and reporting for the project. Other systems development services, systems consultants and equipment suppliers were contracted for by BC Transit as required.

APPROACH

Since the custom transit operators in Vancouver were relatively small and independent, the approach was to provide them with inexpensive personal computers and appropriate software for testing. Two different software applications were demonstrated. One of the applications, the DART Manager Graphics program, utilizes low-cost graphical display technology to improve the scheduling/dispatching function in shared-ride transportation environments. Operating on a local area network, the system can provide a graphical display of available vehicles and current trip demands as an aid for schedulers. It can also operate on a single-user computer without the graphical display. The other application, originally called DART Manager, was a software package that provided assistance in client registration, trip reservation and management information. This application was upgraded to provide scheduling assistance through a tabular display of schedules for the operator. It operates on a single-user computer and also has the capability of operating on a multi-user microcomputer system.

The first step in the demonstration project was to develop and test these two computer packages at the two selected custom transit operators. The two systems were developed and tested in an operational environment, but this process took considerably longer than anticipated. For small operators who require only one workstation, there is little difference between the two systems. For larger operators, the difference lies in the configuration of the computers to operate the programs - one operates under a single-user environment on a local area network and one operates under a multi-user environment.

TECHNOLOGY

Based on the requirements of the Transportation Development Centre for systems that could be easily transferred to other special transit operations in Canada, the Steering Committee decided that the software should be developed for IBM PC microcomputers and compatible units.

DART Manager Plus

BC Transit's Dial-A-Ride Transit Manager (DART Manager) was chosen for use in the New Westminster-Burnaby-Coquitlam suburban area. BC Transit had developed this computer-aided registration, trip reservation and management information system starting in 1983 in Victoria. Because the test operator, the Western Society for Senior Citizens' Services, employs 16 vehicles, the software was modified to operate on a multi-user microcomputer system with two or more terminals using a Xenix operating system. The function of the original system was to provide computer-assisted aids to register clients and to reserve trips. After addition of multi-user capabilities, the system was enhanced to provide improved scheduling features through the display of a scheduling screen which shows vehicles and vehicle assignments for each day and time period. Easy keyboard strokes allowed managers to check on vehicle status and instantly assign passenger trips.

Major functions in the system can be divided into two categories: (1) client registration/trip reservation and (2) operations monitoring. Although the actual scheduling of trips is a manual procedure, the system assists in storing, retrieving and displaying client registration/trip reservation information (e.g. client information, trip requests, daily trip sheets) used to assist in the scheduling process. The operations monitoring function assists in analyzing daily trip logs and producing vehicle statistical summaries and performance reports. Major system functions are:

Client Registration: The client master file contains all pertinent personal information on each registrant including a registration number that is automatically generated by the computer. There are 2,800 persons registered to use the service provided by the Western Society with 25-30 new clients being added each month. The computer provides rapid access to this data by either client number or name. It also ensures that everyone who uses the system has been registered. Information can be added, deleted or changed easily.

Trip Reservation: The system provides several trip reservation functions: (1) subscription trip requests, (2) advance booking trip requests, (3) cancel, change or query trip, and (4) display trips currently booked for a client. It is designed to require minimum operator input. In the trip request procedure, the operator enters the registrant's number or last name which produces a split screen display of registrant and trip

information. The computer prompts whether the trip is outgoing or incoming. If the trip is outgoing, data from the registration file (e.g. name, origin address) is used to supplement user input. For incoming trips, data from the previous trip is used (e.g. pickup and dropoff addresses). The use of a trip expiry date allows input of both subscription and reservation type trips. The system can be purged of all trips that have expired, and the start and stop dates of a subscription trip can be input in order to temporarily suspend a trip.

Scheduling Function: The original DART Manager program did not actually schedule trips. As subscription and advance booked trip requests were entered into the system, a trip ticket was printed which was used in conjunction with trip scheduling boards. Each board, representing a day of the week, was organized by vehicles (columns) and 30-minute time slots (rows). The boards provided the scheduler with a visual summary of vehicle loads by time of day. After the trip was scheduled, the assigned vehicle number for the trip was entered into the computer to allow printing of daily trip sheets.

The major modification incorporated into the enhanced DART Manager Plus was a display of scheduling board information on the video screen. The screen provides a summary of vehicle activities. Within each time slot for each vehicle, the screen displays the number of passengers and location by zone of the vehicle. The operator thus has the information necessary to assign trips to vehicles and can easily scroll through the list of vehicles or transfer between screens (from trip booking to trip assignment). After trips are assigned, daily trip sheets for the drivers can be produced.

Report Generation: On a daily basis, the Delete Subscriber and Daily Trip reports are produced. The Daily Trip Report contains information necessary for drivers to proceed with their daily runs. Daily, monthly and year-to-date reports on vehicle statistics (ridership, hours, kilometres, etc.) are also available. Another report, Client Statistics, groups clients by disability and zone as well as providing a breakdown by trip type. The system is also capable of printing client mailing labels by either zone or registration number.

Operations Monitoring: During and at the end of each day, the trip file is updated to reflect what actually takes place on the road. After information on fuel usage, distance travelled and shift time is added, the computer has all the necessary information to produce the monthly statistics report. Vehicle and system information is available by day, month and year-to-date.

A monthly report on each vehicle provides a comparison of vehicle utilization. The supervisor is able to adjust schedules based on this information to ensure that all vehicles are well utilized. A comparison of vehicle kilometres and passengers carried

provides the drivers with an indication of workloads. The breakdown of ridership by vehicle by day assists in the allocation of trips to vehicles. A report on the fuel efficiency of each vehicle highlights major deviations and possible mechanical problems.

DART Manager Plus is written in RM-COBOL, a standard business application language. Other computers are capable of running this program with little or no modification, although the application program must be recompiled on a new computer. DART Manager Plus runs on any IBM PC, PC/XT, PC/AT or 100-percent compatible unit running under XENIX or DOS 3.1 with 384KB to 640KB of RAM with one floppy drive and a hard disk. The system can maintain vehicle schedules for up to 64 vehicles.

DART Manager Graphics

A colour graphics scheduling system developed by the Stanford Research Institute of California for the United States Urban Mass Transportation Administration was selected for testing at North Shore handyDART. The heart of this software is an interactive computer-aided graphics display for vehicle scheduling of both real-time and advance-reservation trips. DART Manager Graphics handles client registration, passenger reservations and management reporting. The colour graphic display of vehicles and trips overlaid on a service area map gives both time and distance information at a glance. This immediate feedback on the impacts of alternative trip assignments helps managers make scheduling decisions.

Data Base Structure: Each real-time process runs as an independent program under the operating system and communicates with a shared set of files. The largest files include: subscription trips for each day of the week, a dated file produced by copying the subscription file and adding advance trips, and a daily file that includes demand trips for that day.

Order Taking Module: The order taking system is designed to require a minimum of operator input and to prevent errors.

At every command level, a menu of possible options is displayed. A single character suffices to select a command. When entering data, the user cannot overwrite protected fields on the screen and is warned by messages if the input is unreasonable. At every stage it is possible to abort and escape to the next highest command level.

The order taker interacts with the monochrome monitor and the keyboard. A standard order taking form is displayed at the terminal. The order taker enters the caller's phone number and name, pickup and dropoff addresses, number of passengers, and any special remarks (usually by entering only the first couple of letters of the person's name, thereby copying information from the client's file). The pickup and dropoff addresses are

converted to x-y coordinates using an address translation file based on a map coordinate system. Return trips are booked by pressing a "duplicate address" key to reverse the origin and destination of a trip.

Scheduling Module: The scheduling subsystem displays the primary information including such key data as pickup and delivery sequence, vehicle assigned, and location of vehicle for all requests and vehicles that are to be scheduled in the current time frame. The scheduler makes decisions based on the spatial and time information provided by either the textual display or the graphical display.

The location of the pickup and delivery stops, promised pickup and delivery time, and the passenger's need for a wheelchair are provided by the order taking function. The scheduling subsystem automatically calculates and updates the estimated pick-up and delivery stop time for all requests and checks vehicle capacity.

A static scheduling procedure may be used when all requests for service are known at least a day in advance; a 'fast' function can be used to schedule the trips. If only a few requests are known in advance, they are easily handled one at a time either with the keyboard and the textual display or the graphical display and the mouse (note: the mouse is a small hand-held input device for moving a cursor on the video screen). The use of the mouse and the graphical display permits the scheduler to test a variety of different assignments quickly.

Dispatching Module: Both a stop list (for the dispatcher) and a trip sheet (for the driver) are produced when all scheduling assignments for the day have been made. The dispatcher can interact directly with a dispatch display, a monochrome monitor, and the keyboard. The dispatching screen displays the next three stops for each in-service vehicle, including the address, arrival time, and number of passengers to be picked up or dropped off for as many as ten vehicles.

The dispatching function is divided into three independent functions. One is to relay information from the dispatching display to the driver, another to relay information from the driver, and the other to maintain vehicle status data.

Management Information System: The basic input for all reports is collected automatically by the order taking, scheduling and dispatching functions. These reports are produced using information obtained from the soft-copy log of all the daily transactions. Standard MIS programs have been developed.

The MIS programs are written in dBase III so that they can be adapted to an individual operator's requirements, and individual ad hoc reports can be easily obtained. The standard reports produced by the MIS programs include: a daily operational summary, a monthly operational summary and a monthly operator's

invoice (for billing a funding agency). The information used in producing the reports is derived from the booking, scheduling and dispatching functions and corrected, where necessary, from the individual driver trip logs.

DART Manager Graphics is written in Microsoft Pascal, but using a number of tools and procedures from the Turbo Pascal toolkit. DART Manager Graphics runs on any IBM PC, PC/XT, PC/AT or 100-percent compatible running under DOS 3.1 with 640KB of RAM and one floppy drive and a hard disk. It can also be used with a local area network using the Novell software and 3-Com hardware. The capacity limitation of the system is about 500 passenger trips per day.

IMPLEMENTATION

If a new system can be successfully sold to end users, they are more likely to become partners in - not adversaries to - the change. By becoming partners in the change, users feel more like owners of the system and are more motivated to use it effectively. Training helps users overcome their awkwardness, fear, suspicion, and technical ignorance. End-user training teaches users how to perform the procedures necessary to use the new system. One-to-one instruction was the method chosen for this project. In this method, the user is seated at a terminal and the trainer explains and demonstrates the operation of the equipment and the applications used in the job. The user, after this explanation and demonstration, learns by doing under the guidance of the trainer.

This method was deemed best because it is the most flexible, accommodating the user's experience, learning rate, and the fears as well as the depth of the material to be learned. It also gave user and trainer immediate feedback, allowing the trainer to respond to the user's questions.

Several follow-up training services were provided. First, users were told who to call to resolve problems quickly. Second, each user was periodically contacted, usually in person, to see how the system was working and to see if there were any problems that need resolving. This is a step that was continuously under-estimated in this project. The amount of time spent in follow-up training was considerable. For the first six months after implementation, a knowledgeable person had to visit the site twice a week for one or two hours. Even after the system had been operating for some time, a visit once a week was necessary.

Good user documentation provides backup and reinforcement to users' training. User documentation for each of the computer systems consisted of a manual with detailed instructions on how to install the system and how to use it for registering clients, reserving trips, scheduling trips and dispatching vehicles.

Hardware acquisition and installation involved other concerns: Is the order complete and according to specifications; has the vendor tested the equipment before delivery and are all the connections working? This is especially important if a local area network or a multi-user system is being implemented. On this project, the vendor was made responsible for making sure that the equipment was working properly prior to delivery so that the project team could be assured that any problems could be attributed to the software and not the hardware.

Installation at the offices of the custom transit operators required additional equipment including: a separate electrical outlet for the computer, air conditioning, computer tables, and cabinets to store the floppy disks. An aspect of systems installation that should not be overlooked is the purchase of computer supplies such as paper sheets, tapes, disks, cards, log books, printer ribbons and cleaning equipment.

Contingency plans were developed to support computer operations during disaster recovery, including having backup equipment and storing all necessary key records, files, and supplies in a different location so as to recreate the latest master files and re-start system operation. Copies of the system programs were kept in two other locations, and tape backup systems were installed to ensure that all data files could be replaced with minimal disruption.

The ongoing system testing and acceptance during the development process were finally completed when the operators and the project team were satisfied that the systems were "working" properly with no "bugs" or system interrupts during normal operations. In March, 1987, after about a two-year development process, both computer systems were deemed to be successfully operational. The sequence of significant events during this project is summarized as follows:

May 1, 1985	Request for Proposals for supply of computer systems issued to seven suppliers.
Aug 2, 1985	Contracts awarded to AIM Software for multi-user version of DART Manager and SRI International for a systems analysis of Pacific Transit's operations.
Sep 18, 1985	Purchased hardware for DART Manager Plus.
Oct 7, 1985	Installation of multi-user version of DART Manager at Western Society.
Nov 6, 1985	Contract awarded to SRI International for DART Manager Graphics.
Nov 19, 1985	File creation/staff training for multi-user DART Manager.

Nov 28, 1985	Purchased hardware for DART Graphics.
Dec 2, 1985	Begin operations at Western Society with multi-user version of DART Manager.
Jan 7, 1986	Contract awarded to AIM Software for DART Manager enhancements (Plus).
Feb 19, 1986	Order entry module of DART Graphics installed at Pacific Transit Cooperative.
Mar 11, 1986	File creation and staff training for DART Manager Graphics at Pacific Transit.
Apr 15, 1986	Debugging of both DART Manager Plus and Graphics.
May 6, 1986	Scheduling module of DART Manager Graphics implemented at Pacific Transit.
May 22, 1986	Installation of DART Manager Plus at the Western Society.
Jun 19, 1986	DART Manager Graphics moved to new location at North Shore handyDART.
Jun 30, 1986	File creation and staff training for staff at new location.
Jul 28, 1986	Operations planned for North Shore but are delayed due to bugs in program.
Sep 10, 1986	Contract awarded to AIM Software for additional modifications to DART Manager Plus.
Nov 4, 1986	A new version of DART Graphics is installed.
Nov 14, 1986	Modifications for DART Plus completed.
Nov 16, 1986	Full operations for DART Graphics are planned but delayed due to staff holidays.
Dec 3, 1986	Installation of modified DART Manager Plus.
Jan 6, 1987	Operations begin with DART Manager Plus but are delayed due to system crashes and data corruption.
Jan 23, 1987	New version of DART Manager Graphics is installed and operations are planned to begin but are delayed due to contract negotiations.
Mar 9, 1987	Full operations with DART Manager Plus at Western Society and DART Manager Graphics at North Shore.
May 1, 1987	Completion of user manuals for distribution to other operators in Canada.

The demonstration project was completed within the original budget estimate, but all activities occurred considerably later than anticipated - in fact almost one year later (or twice as long as anticipated). Reasons for the delay were a number of unforeseen events and circumstances including:

Change in Structure of BC Transit: During the demonstration project, a major organizational change occurred that affected all participants. BC Transit amalgamated with the Metro Transit Operating Company and the organization moved its administration facilities to a new location.

Change in Venue for the Demonstration: One of the computer systems was initially installed at Pacific Transit Cooperative in the City of Vancouver. In June, 1986, the size of Pacific Transit's operation was more than doubled, taking it well beyond the current capacity of DART Manager Graphics. It was concluded that a more suitable and stable test site was necessary and this system was subsequently re-installed at North Shore handyDART.

Decision to Use Leading Edge Technology: Quite a few minor problems occurred related to a conscientious decision to implement the software applications on hardware that, at the time, was on the leading edge - the PC Network for the local area network application and the Xenix operating system for the multi-user application. Both of these systems experienced a number of "bugs" that were as much a problem of the manufacturers as they were of the software developers. The first IBM PC ATs had hard disk problems also.

EVALUATION

The systems were evaluated to determine the best alternative for expansion to other custom transit operators in the Vancouver area and for coordination between operators. In addition, the alternatives were evaluated to determine the overall benefits and costs of applying computers to special transit services. The alternatives were:

- Manual Systems, the baseline alternative signifying the existing or "before" situation in which no computer system was used;
- DART Manager Plus, the single- or multi-user version of the enhanced Victoria computer system using a textual or tabular display of time-oriented information to assist with the scheduling process;
- DART Manager Graphics, the single-user or local area network version of the SRI graphical display system for computer-aided scheduling and dispatching, using the computer as an information display device to aid in the decision process.

The "Manual Systems" alternative was considered to be the "before" situation occurring in fiscal year 1984/85 - April 1, 1984 to March 31, 1985. The "DART Manager Plus" and "DART Manager Graphics" alternatives were the "after" situation occurring in fiscal year 1986/87.

The criteria used in this evaluation were developed from three different viewpoints: the transit operator, the overall transit service, and the funding agency, and include:

- Effectiveness, to assess the (non-quantifiable) impacts of the alternatives on computer system users in terms of system reliability, ease of implementation, ease of use, level of operator sophistication required, employee morale, reductions in workload, reduced stress and tension, assistance required, etc.

- Efficiency, to measure the quantifiable impact of the alternatives in non-monetary terms on the overall operating efficiency of the transit service in terms of passengers per hour, kilometres per hour, deadhead kilometres, passengers per vehicle, trip requests per office staff, and other suitable transit service performance measures.

- Economy, to measure the quantifiable impact of the alternatives in terms of an overall cost-benefit effect on the transit service funding agency. Costs include computer system acquisition and benefits include the additional passenger trips that could be carried for the same budget.

Effectiveness

Quality of Service: Use of computers in a custom transit office made it easier and faster to record trip requests with less chance of making mistakes or misplacing the resulting trip request. It also made it easier, faster and more accurate to respond to requests about the status of a client's trips and related information. It was concluded that the application of computers improved the quality of service to users.

Flexibility of Operations: More flexible operations were seen as a potential benefit of computer operations; that is more service could be provided with no additional office staff. This occurred at the Western Society where two additional vehicles were added with no office staff increase.

DART Manager Plus, installed at the Western Society, is considered to be very flexible. As a true multi-user system, additional terminals can be inexpensively attached as system operation expands (up to eight terminals). DART Manager Graphics is also flexible since it can operate with or without the graphics display terminal and it can also be expanded with the addition of a local area network.

Administrative Requirements: The additional administrative requirements of a computer system should not be underestimated. Learning about the computer and the programs, staff training, resolving hardware and software problems, and revising and enhancing the system are all time-consuming.

The version of DART Manager Plus which uses the Xenix operating system generates additional implementation and administrative requirements. The Xenix operating system is not one that can be used by most managers of special transit systems and outside help would be required to install the system. DART Manager Graphics operates under MS-DOS which is more user-friendly. The local area network requires additional help which can be supplied by the network vendor.

System Response Time: Tests were conducted to measure system performance. The number of keystrokes and time required to complete various functions on each computer system were measured. This comparison indicates that DART Manager Graphics requires fewer keystrokes and generally less time to accomplish typical special transit functions and should facilitate quicker trip booking and scheduling.

In comparing response times to the manual system, no clear conclusions were drawn. With most manual systems, incomplete information is often taken (other trip information may be mentally stored by the call-taker). The response time in recording a trip request may be faster manually but the information is incomplete. Certainly the computer systems are almost as fast if the operator has good keyboard skills.

Improved Information: The computer systems most definitely increased the volume of information available, speeded up its retrieval and improved its accuracy. Better information is one of the most obvious benefits of computers, but it is difficult to assess because it is less tangible.

Improved Morale: Although this factor is even more difficult to define, it is believed to be worth mentioning. The attention that is drawn to operators when a new computer system is being implemented seems to increase the morale of the office staff considerably - in spite of the stress that naturally results from a re-definition of work from a manual to computer system.

Efficiency

Productivity or passengers carried per hour is a good measure of efficiency. Productivity increased by 9.1% with DART Manager Plus and 2.1% with DART Manager Graphics. Since the regional productivity increase was 4.1% over the same time period, no more than 5.0% of the increase for DART Manager Plus can be attributed to the computer. This productivity increase was not realized at the DART Manager Graphics installation since this system was implemented much later in the demonstration project.

Economy

The cost of hardware for the DART Manager Plus system was $11,729 plus $859 for each additional terminal attached to the system. At the time this hardware was purchased, a single-user system cost $11,729 and a typical small multi-user system with three workstations cost $13,447.

For the basic DART Manager Graphics hardware without the graphics terminal, the cost of $11,454 was about the same as DART Manager Plus. With the addition of a graphics terminal, the cost of the single-user system was $18,354, and each additional workstation cost $5,850.

The operating cost per passenger declined by 1.4% with DART Manager Plus and 3.4% with DART Manager Graphics. At the same time, for the Vancouver system as a whole, the operating cost per passenger increased by 3.0% in constant dollars. Therefore, the decline in operating cost per passenger could be taken as 4.4% and 6.4% respectively for DART Manager Plus and DART Manager Graphics.

If the operating cost saving per passenger is multiplied by the number of passengers, the resulting figure gives an indication of the value of the extra service that could be provided with the savings resulting from the improvement in productivity and reduced operating costs. Ridership increased by 18.8% over the period of the demonstration project with the DART Manager Plus installation and 18.5% with the DART Manager Graphics system. Since total regional ridership increased by 20.8% in the same period, from 382,473 to 462,186 annual trips, it is not possible to attribute these increases to the computers.

Based on this service ridership, the operating cost savings translates roughly into an annual benefit of $39,300 for the DART Manager Plus system and $26,000 for the DART Manager Graphics installation. To see if this saving is due to an increase in productivity or to lower wage rates, the operating cost per hour was examined. The operating cost per hour (in constant dollars) increased 7.6% for the Plus installation and decreased 1.5% for the Graphics installation. Therefore, the benefits for the Plus system are probably underestimated and overestimated for the Graphics system.

Acquisition cost of the computers is compared with the annual benefit (i.e. operating cost reduction) in the following table:

Operator	System	Initial Cost	Annual Benefit	Payback Period
Western Society	Plus	$13,447	$39,300	4 months
North Shore	Graphics	$18,354	$26,000	8 months

As shown, investment in a computer-aided scheduling system (assuming that there are no large system development or software customization costs) should result in savings that would more than pay for computer acquisition within one year. This analysis shows that, with the low cost of small personal computers, the resulting benefits do not have to be large to make it worthwhile to employ public domain software in a computer-assisted system.

The application of computers to custom transit operations in Vancouver resulted in an initial improvement in productivity of about five percent. This resulted in a reduction in the operating cost per passenger of about five percent. An annual benefit equal to an additional five percent more trips per year is the result. For an operator who serves 100,000 trips a year, the annual benefit is equal to approximately $50,000 at $10 per trip. If all the operators in the Vancouver region were to experience the same benefits, the annual benefit would equal about $150,000 per year. This would more than pay for the cost of acquiring computers for all seven operating organizations.

The evaluation which attempted to define which of the two computer systems was better than the other was not definitive. Both systems have advantages and disadvantages that make it difficult to choose between them. It is recommended that any interested operator should actually test each system and then decide which fits best with their established operating procedures.

An operator with fewer than ten vehicles would probably choose between the single-user version of DART Manager Plus and the single-user version of DART Manager Graphics (possibly without the graphics terminal). For an operator with more than ten vehicles, the choice would be between the multi-user version of DART Manager Plus and the local area network version of DART Manager Graphics with the graphics terminal.

CONCLUSIONS

The specific objective of this demonstration project was to improve the quality and cost-effectiveness of transit services for disabled persons through the selection, implementation and demonstration of computerized scheduling/brokerage systems, with particular emphasis on the best application of microcomputer technology to the personalized form of transportation offered by special transit services.

Emphasis was placed on the application of technology to an existing organizational and operational structure. It was anticipated that coordination and increased efficiency would result by providing each operator with a microcomputer with appropriate software and then connecting the various computers with an electronic network so that they could better communicate with each other.

To develop and test this application, computer programs were acquired and placed in an operational environment where the potential users would have an opportunity to test them and provide appropriate feedback to the developers. This process took considerably longer than anticipated but the resulting systems are probably better as a result of the interest and active involvement of both the users and developers.

Due to time constraints, the "electronic coordinating network" was never implemented or tested, although during the project various commercial network "gateways" and "inter local area network" products became available which would make such a concept technically feasible. Whether or not it would work from an operational point of view is still to be proven.

These two computer software packages should allow other operators in Canada to improve the way that they handle information. Internal office improvements should then translate into overall system productivity improvements that will allow more service to be provided to the users of the service at less cost.

For office staff - the call-takers, dispatchers and schedulers - paperwork is greatly reduced with computers. Accuracy and reliability of information is improved as mistakes from hand-written entries and notes are reduced. It is easier to train new staff with a computer system in place. Drivers don't have to copy out their daily run sheets, which also saves time and effort.

Lead time requirements for advance bookings are reduced since schedules can be developed in a shorter time. For example, North Shore handyDART previously required 48 hours advance notice to book a trip. Bookings are now accepted up to 3 PM the day before the trip (i.e. 16 to 26 hours advance notice). Scheduling of next day's trips is accomplished between 3 and 5 PM and driver run sheets are printed as soon as the schedules are completed.

Once a computer system is in place, some operators have also found that they can easily add more service with no additional office staff requirements. One of the operators in Vancouver, for example, added two additional vans with no additional office staff.

The introduction of a computer system can reduce the average telephone dwell time for trip reservations - improving the quality of service for the user as well as increasing office staff productivity. Clients' requests for trip status and other information are also handled more quickly and easily. For example, the time to book and schedule a trip manually was measured at 3.9 minutes. The same procedure averaged 1.4 minutes using DART Manager Graphics and 2.5 minutes using DART Manager Plus.

The implementation of a computer system should improve accuracy and timeliness of management information. Reports are naturally easier to produce with the assistance of a computer to retrieve and tabulate data. The raw data, once entered into the computer, can be tabulated and presented in a variety of formats to make it easier to monitor and manage service in a cost-effective manner. Better reporting also ensures better accountability for the funds expended on the special transit service.

The computer-aided scheduling systems in Vancouver were developed using public funds with a provision that the resulting software packages would be placed in the public domain at the end of the project. They were also developed for a hardware configuration that, at the time, appeared to be the most common for business applications - the IBM PC and compatible computers.

The project ensured that software packages for assisting operators of special services (DART Manager, DART Manager Plus, DART Manager Graphics) would be available to other jurisdictions in Canada at a nominal cost. This attempt at developing generic software will help other small special transit operators in Canada to realize the benefits that some large operators have already achieved in developing their own site-specific systems.

In summary, the following conclusions were derived from the results of this computer-aided scheduling/brokerage demonstration project:

1) The use of computers by small operators of special transit services does improve office efficiency which is translated into service productivity improvements and/or cost savings.

2) Two systems were successfully implemented. Each meets the operational requirements in a different way. Since each operator has a unique method of scheduling and dispatching, potential users must decide which system is preferable.

3) The development and testing of computer systems takes considerably longer than expected. The process also requires more support by technical and project management staff than anticipated.

4) User involvement in the selection (or development and testing) of computer systems is absolutely essential and the interest and involvement of the users in Vancouver was a key reason for the success of the systems.

5) Automatic trip scheduling "suggestion" techniques would greatly enhance the effectiveness of the computer systems since these would allow operators to provide immediate information in response to client trip requests.

Finally, the following recommendations result from the demonstration project in Vancouver:

1) BC Transit (and possibly other provincial transportation agencies) should establish an information centre to provide ongoing advice and support for special transit service operators in their own jurisdictions who decide to implement computer scheduling systems.

2) BC Transit should establish a Vancouver regional communications network so that operators with computers can more easily exchange information related to trip requests that pass beyond a local operator's service area.

3) If the software packages find wide application throughout Canada, Transport Canada should investigate potential improvements such as heuristics for automatic trip assignment suggestions.

4) If the software packages find wide application throughout Canada, the operators should form a user group that could act as an advice and support centre for themselves.

5) The DART Manager Graphics package should be enhanced to include an automatic trip scheduling technique so that operators can provide immediate confirmation of trip requests to clients.